

# NASA TECH BRIEF

## *Marshall Space Flight Center*



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### Program to Determine Space Vehicle Response to Wind Turbulence

#### The problem:

The proper assessment of winds aloft is one of the most difficult and most important launch vehicle, flight-operations problems. Previous assessments have considered peak wind velocity and wind shear, but have provided no definition of how the wind might affect the vehicle in terms of response. It must be shown statistically that there is a good chance for a safe vehicle launch a given number of hours from a given time.

#### The solution:

A computer program was developed as a prelaunch, wind-monitoring tool. The program accounts for changes in wind characteristics such as turbulence power spectral density, wind shear, peak wind velocity, altitude, and direction using stored variational statistics.

#### How it's done:

The program uses Jimsphere (a spiked weather balloon, see T.B. 65-10326) wind data measured at the launch site shortly before launch. The high-frequency turbulence is filtered from the low-frequency wind variations. A turbulence power spectral density (PSD) is computed as a function of the wave number. To account for inaccuracies in data and changes in the wind, an envelope of the peaks of the turbulence PSD is used, rather than the actually measured PSD. In addition, the PSD envelope is scaled by a factor of three to approximate a "three sigma" bound since turbulence has a zero mean.

Using the smoothed wind profile, a 6-D rigid-body trajectory program is run, and the vehicle response is computed as a function of flight time. Vehicle turbulence response PSD and total response are computed at all

times. The response is compared with allowables and the most critical times are noted.

Using stored variational statistics on how winds have changed in the past, a synthetic wind profile and turbulence PSD having the desired probabilities of non-exceedance at the desired time are constructed, and the vehicle response is computed. If no allowables are exceeded, there is a given probability (e.g., 95%) that it will be safe to launch at the given time in the future (e.g., 8 hrs.).

If any allowables are exceeded for the selected set of probabilities, another set giving a lower total probability of nonexceedance is selected. This is repeated until no allowables are exceeded. The program then interpolates to find the exact probability of a safe launch.

The program was developed primarily for the Saturn V/Apollo launch vehicles but could be applied to other launch vehicles with minor modifications and proper data.

#### Notes:

1. The program is written in FORTRAN IV language to be utilized on the CDC-6500 computer.
2. Inquiries concerning this program should be submitted to:

COSMIC  
112 Barrow Hall  
University of Georgia  
Athens, Georgia 30601  
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